STORM DRAINAGE

DESIGN

STORM DRAINAGE DESIGN REQUIREMENTS

construction plans and stormwater management plans

In order that the Engineering Department may adequately review preliminary ~~subdivision~~ plats, the following items should be indicated or accounted for on all plans submitted for approval:

Stormwater Management Program

and the NC Division of Water Quality Stormwater Best Management Practices Manual

D-1 All storm drainage facilities shall comply with the requirements as stated in the ~~Storm Drainage Policy~~ for the City of Greenville, ~~Resolution No. 192 or the latest revision thereof.~~

D-2 Storm drainage pipes to be designed for a 10-year storm (post-development), catch basins to be designed for a 2-year storm. (post-development)

D-3 Mininum storm drainage size is 15 inches.

D-4 Double basins are permitted.

D-5 Minimum allowable velocity is 2.5 feet per second for concrete pipe or corrugated metal pipe. Maximum velocity is 10 feet per second within a system. Exiting velocities shall be in conformance with the Sedimentation and Erosion Control Ordinance of the City of Greenville or the latest revision thereof.

D-6 Drainage pipes which are located parallel or near parallel to public streets shall be contained within street rights-of-way. If this is not possible, dedicated storm drainage easements shall be required ~~on the following scale:~~ as defined on STD. NO. 15.01a.

PIPE	EASEMENT
15"	10'
18"	15'
24"	15'
30"	20'
36"	20'
42"	25'
48"	25'
54"	30'
60"	30'
66"	30'
72"	30'
>72"	to be determined by City Engineer

REPLACED WITH STD. NO. 15.01a.

D-7 In cases where two ditches intersect at perpendicular or obtuse angles, erosion control measures must be indicated.

D-8 Headwalls or flared end pipe will be required at the influent and effluent of all pipe systems.

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GENERAL NOTES:

~~1. FOR STREAMS CARRYING 500 ACRES OR MORE OF SURFACE RUNOFF, THE EASEMENT REQUIREMENT IS TO BE THE WIDTH OF THE STREAM FROM TOP OF BANK TO TOP OF BANK, PLUS (+) 10' ON EACH SIDE OF STREAM. (40' MINIMUM WIDTH)~~

1. ~~2.~~ FOR OPEN CHANNELS THE MINIMUM EASEMENT MUST CONTAIN THE WIDTH OF THE STREAM FROM TOP OF BANK TO TOP BANK. PLUS (+) 10' ON EACH SIDE OF STREAM.

2. ~~3.~~ WIDER EASEMENT WIDTHS MAY BE REQUIRED FOR PIPE DEPTHS GREATER THAN ~~TEN~~ EIGHT FEET.

3. ~~4.~~ PIPE SYSTEMS AND OPEN CHANNELS ON PRIVATE PROPERTY SHALL BE PLACED IN A STORM DRAINAGE EASEMENT.

Easement Requirements for Open Storm Drainage Channels

Area in Acreage	Easement Requirement
0–45 ac.	20'
45–~~120 ac.~~ +	30'
120–500 ac.	40'
~~500 ac.+~~	~~see note~~

Easement Requirements for Storm Drain Pipe

Pipe Size	Easement Requirement
15"	15'
18"	15'
24"	15'
30"	20'
36"	20'
42"	25'
48"	25'
54"+	30'MIN (VARIES)

NOT TO SCALE

MINIMUM DRAINAGE EASEMENT REQUIREMENTS FOR STORM DRAIN PIPES AND OPEN CHANNELS

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topography,

at least every 100' and/or if there is a significant change in either.

D-9 Indicate all ditch sections with cross sections and grades.

D-10 Indicate ditches, pipes, swales, and drainage easements which are adjacent to the proposed project.

~~D-11 Storm drainage systems shall be designed to carry a 10-year storm.~~ (DUPLICATE)

Spread shall be 4 feet.

D-12 Catch basins shall be placed such that the ~~maximum~~ depth of flow in the gutter ~~shall be 0.50 feet~~ on private, marginal access, and minor streets. The ~~maximum depth of flow~~ spread on collector streets and thoroughfares shall be ~~0.30 feet.~~ 3 feet.

is based on allowable spread.

Maximum depth of flow in the curb and gutter for all streets shall never exceed 6".

D-13 With all storm drainage designs, the following design data must be submitted for each run of pipe.

(a) area drained
(b) design storm intensity adjusted for duration
(c) design flow
(d) coefficient of runoff
(e) grade of pipe
(f) type of pipe
(g) size of pipe
(h) velocity of flow
(i) Maximum Capacity
(j) Hydraulic grade lines

D-14 Not more than one acre may drain into the street at a single concentrated point.

~~D-15 Typical sections and specifications of open ditches shall be indicated.~~

D-16 Slotted drains are permissible with prior approval of the Engineering Division.

D-17 The minimum grade for any storm drainage pipe shall be 0.3%. (In the event that this requirement cannot be met, the City Engineer may approve an alternate)

~~D-18 The invert of the outlet of a manhole or catch basin shall be).10 feet lower than the invert of the inlet plus 0.10 foot for each additional inlet.~~

(STD. NO. 25.03)

ADD

Any storm drainage system to be city-maintained shall have "Record Drawings" submitted and approved prior to scheduling of the pre-final street acceptance inspection. All "Record Drawings" for storm drainage infrastructure shall include, but not necessarily limited to, the information as identified in the *Street and Storm Drainage "Record Drawings" Submittal Requirements.*

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AASHTO M86

REQUIREMENTS FOR INSTALLATION OF REINFORCED CONCRETE PIPE

1. ~~ASTM~~ Designation ~~C-76~~ (or the latest revision) shall apply to all reinforced concrete pipe.
2. All pipe installed within the street right-of-way shall be Class III or higher.
3. Mortar mix of one part Portland cement and two parts sand shall be applied to the outside of all pipe joints and to both inside and outside of joints of pipe eighteen inches (18") in diameter and larger. Joints shall be wiped smooth.
4. A roughness coefficient of 0.013 ("n" factor) shall be used in the design of reinforced concrete pipe drainage systems.

M196

REQUIREMENTS FOR INSTALLATION OF CORRUGATED METAL PIPE

1. AASHTO Designation ~~M36-78~~ or the latest revision thereof shall apply.
2. ~~All corrugated metal pipe shall be fully asphalt coated inside and outside according to AASHTO Designation M190-78.~~ (REPLACE)
3. Coupling bands shall be used at all joints and shall be of a size specified by the manufacturer in accordance with the pipe design. ~~Bands will be fully asphalt coated on both sides and~~ Bands shall conform to AASHTO Designation ~~M36-78 and M190-78.~~ M 196 Bands to be of Hugger-Type or approved equal.
4. Pipes shall meet the NC-DOT specifications for loading requirements.
5. ~~The following~~ A roughness coefficient~~s~~ of 0.024 ("n" factor) shall be used in the design of corrugated metal pipe drainage systems~~:~~.

CORRUGATIONS		ROUGHNESS COEFFICIENT "n"
a.	$2\frac{2}{3}$" x $\frac{1}{2}$"	0.021
b.	3" x 1"	0.023
c.	6" x 2"	0.026
d.	125mm x 25 mm	0.023
e.	fully paved	0.013

2. all corrugated metal pipe shall be aluminum unless coating of steel pipe is approved by the City Engineer.

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f. spiral pipe

15"	0.013
18"	0.014
21"	0.015
24"	0.016
30"	0.017
36"	0.019
42"	0.020
48"	0.020
54"	0.021
60"	0.022
>60"	0.023

COMPACTION AND BACKFILLING

Compaction for reinforced concrete pipe and corrugated metal pipe to be in accordance with Sections 300-6 and 235-4(C) of the NC-DOT Standard Specifications for Roads and Structures.

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STORM WAT... DESIGN CALCULATIONS

~~DESIGN PROCEDURE FOR~~ RUNOFF DETERMINATION:

~~There are two distinct and separate steps to storm water design. The first is to determine the amount of water discharged at the point of design.~~ There are two acceptable methods: (1) Rational Method (good for areas less than ~~150~~ 20 acres) and (2) Soil Conservation Service Method using Curve Numbers. ~~This first step is basic to the design of any structure. The second step is the selection of a size and design of the system or structure itself.~~

DETERMINATION OF DISCHARGE:

The most widely used method for determining discharge in storm drainage is the Rational Method and shall be the method used for the purpose of this manual. It should be noted, however, that this method should be used with caution since it does not adequately recognize all of the complications of the runoff process. The basic formula may be reduced to "Q = CIA", where:

Q = Discharge, in cubic feet per second
C = "Runoff" coefficient, unitless
I = Intensity of rainfall, inches per hour
A = Drainage basin area, acres

These factors are explained in detail in the following paragraphs.

C.....RUNOFF COEFFICIENT

The runoff coefficient is the proportion of the total rainfall which runs off the basin area into the drainage system. The runoff coefficients to be used for the Greenville area are listed on Chart No. SD-3.

I......INTENSITY

Values for the rainfall intensity for the Greenville area may be derived from ~~Chart No. SD-2 and Chart No. SD-1.~~ The design procedures for runoff for the City of Greenville shall be based on a 10-year rainfall. and storm duration is equal to the time of concentration (Tc).

A.....DRAINAGE BASIN AREA

The drainage basin areas can be calculated with the use of topographic maps by marking the basin ridgeline and planimetering the designated areas. When marking the basin ridgeline, it should be remembered that water runoff flows perpendicular to contour lines.

$$T_c = \frac{\left(\frac{L^3}{H}\right)^{0.385}}{128}$$

L = maximum length of travel of water (feet)
H = difference in elevation between the most remote point on the basin and the outlet (feet)

NOTES: overland flow, grass, multiply Tc by 2.
concrete or asphalt, multiply Tc by 0.4
concrete channel, multiply Tc by 0.2

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Q.....DISCHARGE

After determining the coefficient of runoff, rainfall intensity, and drainage basin area; the discharge can be computed by the use of the rational formula "Q = CIA".

EXAMPLE:

GIVEN: 20 acres Residential Development (R-15). Height of most remote point above outlet = 15 feet, travel length = 1400 feet.

Step 1: Determine the individual drainage area in acres to be considered, = 20 acres (Given).
Step 2: Determine runoff coefficient from Chart No. SD-3 = 0.55
Step 3: From topographic maps, determine the height of the most remote point above the outlet and length of travel. Enter Chart No. SD-2 with a height of 15 feet and a distance of 1400 feet to get a "Time of Concentration" (Tc) of 12 minutes.
Step 4: Enter Chart No. SD-1 with Tc of 12 minutes and a 10-year storm to get an intensity of 6.1 inches.
Step 5: Substitute the above factors in the equation: Q = CIA to obtain a peak discharge (Q) of 67.1 cfs.

CATCH BASIN DESIGN

DESIGN PROCEDURE:

The following procedure for the location and design of catch basins for the City of Greenville is based on the actual hydraulic characteristics of the standard catch basin for the City as depicted in Chart No. SD-4. Catch basin design shall be based on a 2-year storm. Double basins are permitted. The catch basin design data sheet, Chart SD-5 or approved equivalent shall be completed and submitted with each plan.

1 - DETERMINE DRAINAGE LIMITS:

The drainage limits should be calculated by the use of topographic maps by marking the basin ridgeline. It should be noted that the centerline of the streets will usually represent a ridgeline on a normal crown.

2 - DETERMINE DEPTH OF FLOW:

The depth of flow allowed is the depth of the water in the gutter line which will be tolerated in flooding conditions. ~~For the purpose of this design, the maximum depth allowed will be 0.5 feet.~~

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-DETERMINE LONGITUDINAL SLOPE (S_L) OF STREET:

Determine the slope of the street in percent.

4-DETERMINE TRANSVERSE SLOPE (S_T) OF THE STREET:

This can be determined from the typical section of the street and will usually consist of the vertical distance from the gutter line to the crown of the street divided by the horizontal distance from the gutter line to the crown of the street.

5-DETERMINE CAPACITY OF THE BASIN:

The capacity of the basin can be determined by the chart on Chart No. SD-4. Enter the bottom of the chart with the transverse slope and draw a vertical line to the longitudinal slope. Then using this as a turning point, draw a horizontal line to intersect the "K" factor. Then use the equation:

$Q = KD^{5/3}$, where:

Q = the capacity of the basin in cubic feet per second
K = a dimensionaless factor determined from said chart
D = the depth of flow in the gutter line in feet

With this information, complete columns 1, 2, 3, and 4 of the catch basin design data sheet. (Chart SD-5)

6-DETERMINE AREA SERVED BY THE BASIN

STEP NO. 1 : Assume a trial coefficient and a trial intensity for the design area and place these figures in columns 5 and 6 of the data sheet. At this point, an approximate area served by the catch basin may be determined by dividing the catch basin capacity by the trial coefficient of runoff and the trial intensity (column 5 x column 6). This derived area should be placed in column 7 in the design data sheet. This gives an approximate area served by the catch basin. With this area and the topographic lines, a trial location of the proposed basin should be made.

STEP NO. 2 : To insure that the location as derived in Step No. 1 is appropriate and that the trial coefficient of runoff and trial intensity are in order, the runoff for the area determined by the proposed location of the basin should be calculated. This is accomplished by calculating the runoff as established in the storm water design procedures listed in the previous section and completing columns 8 through 13. If column 13 varies by more than 10% from column 7, this would indicate that the trial coefficient and/or trial intensity were not in line with the actual coefficient and intensity, and therefore, the basin is not properly located. The procedure in Step No. 1 should then be repeated and then adjust the trial coefficient of runoff (col. 5) and trial intensity (col. 6) accordingly. Once all the basins have been properly located, the pipe design associated with these basins may be completed according to the PIPE SYSTEMS DESIGN PROCEDURES listed in this chapter.

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EXAMPLE:

Given area shown on Chart No. SD-7.

Step 1: Determine the drainage limits according to the topography as indicated by the broken line (........) on the example.

Step 2: Determine the maximum depth of flow allowed in the gutter, which is 0.5 feet for the City of Greenville.

Step 3: Determine the longitudinal grade of the street from profile plans or topographic maps. From this, the streets were determined to be 1.2%, 1.3%, and 0.6%.

Step 4: Determine the transverse grade of the street from the typical section (for this example, use a 36 foot B/B "Minor" street section). Therefore, the distance from the gutter line to the centerline will be 17.5 feet. For this example, $S_T = 0.5/17.5 = 0.029$

Step 5: Determine the capacity of basin CB-1. Enter Chart No. SD-4 with a $S_T = 0.029$ and a $S_L = 0.6\%$ to obtain a K of approximately 14.0.
Substitute in the equation $Q = KD^{1.67}$

$$Q = (14.0)(.5)^{1.67}$$ to get the capacity of 4.41 cfs.

Enter the above values in columns 1, 2, 3, and 4 of the catch basin design data sheet.

Step 6a: Assume a trial coefficient of runoff and a trial intensity. For the example, assume a lot size of 1/4 to 1/3 of an acre which according to Chart No. SD-3 yields a runoff coefficient of 0.55. Assume a trial intensity of 5.5 inches, and place these values in column 5 and 6 respectively. Determine the derived area (column 7):

$$\frac{4.41}{(.55)(5.5)} = 1.46 \text{ acres}$$

Using the topographic lines, locate the basin so that it will intercept the runoff for 1.46 acres.

Step 6b: Using the location of the proposed basin, regulate the runoff of the area drained by basin according to the procedure listed in "Storm Water Design". Complete columns 8 through 12. The maximum allowable drainage area (column 13) is determined by:

$$\frac{\text{the capacity of the basin (column 4)}}{\text{the actual coefficient (column 10) x the actual intensity (column 12)}}$$

Column 13 must be within $\pm 10\%$ of column 7, ie: $0.9 \times \text{column 7} \leq \text{column 13} \leq 1.10 \times \text{column 7}$ for the example:

$$1.31 \leq 1.54 \leq 1.61;$$ therefore, location is O.K.

CB-1 serves an area of 1.40 acres which is within the allowable range, therefore, basin location is O.K. However, if this were not a valid condition, repeat procedure 6a and adjust trial coefficient of runoff and/or trial intensity to be more consistent with the actual runoff and intensity. Then, repeat procedure 6b as described above.

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CULVERT _SIGN

DESIGN PROCEDURE:

There are two steps in storm drainage design. The first step is to determine the amount of water discharged at the point of design. This can be accomplished by using the "Storm Water Design" section of this manual. The second step is the actual selection of a size for the structure, based on the calculated discharge.

DETERMINATION OF STRUCTURE SIZE:

There are essentially two types of control which must be considered in every culvert design situation: inlet control and outlet control. Both types of control must be considered separately in the design of culverts.

INLET CONTROL:

Inlet control exists in cases where the culvert is not flowing full. The inlet control charts have (SD-a through SD-f) headwater depth as the controlling criteria. Headwater depth is the depth of the water on the upstream side of the culvert, expressed in diameters of the pipe under study.

The maximum allowable headwater is limited by either the controlling flood elevation or existing or proposed development. However, the maximum headwater depth should not exceed 1.2 times the open height of the culvert for a 10-year storm.

OUTLET CONTROL:

Outlet control exists in cases where the culvert is flowing full. Before using the outlet control charts, (SD-g through SD-M) it is necessary to determine the coefficient of entrance loss "Ke". These values are found in the coefficient of entrance loss table on Chart No. SD-11.

A controlling criteria for outlet control is tailwater depth, which is represented in the tables by the amount of "head". Head is the difference in elevation of the water surface on the upstream side of the culvert and the downstream water surface. The tailwater elevation is determined by downstream conditions and may be calculated if these conditions are known. In any case, the tailwater elevation will not be below the design year flood elevation at the outlet. If flood data is not available, the assumption may be made that the tailwater elevation is the crown of the culvert.

EXAMPLE:

(Following Design Procedure for Runoff Determination)

Given: 23.25 acres Residential Development (R-6, R-9). Height of most remote point above outlet = 43 feet, travel length = 1800 feet. (See Chart No. SD-10)

Step 1: 23.25 acres
Step 2: C = 0.60
Step 3: Tc = 11 minutes
Step 4: i = 6.4 inches
Step 5: Q = CiA = 89.28 cfs

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.LET CONTROL

To size for inlet control, enter the chart on Chart No SD-b (use square edge headwall for example). Try a 42" pipe.

Q = 89.28 cfs, D = 42" .... HW/D = 1.7 .... HW = 5.95'

A headwater depth of 5.95' is too large for the existing street elevation. Try two smaller pipes to reduce the headwater:

Q = 44.64 cfs, D = 2 x (36") .... HW/D = 1.2 .... HW = 3.6'

Maximum headwater depth should not exceed 1.2 diameters for the 10-year storm.

Maximum HW = 1.2 (D) = 3.6'

Inlet control checks 3.6' $\leq$ 3.6'

2-OUTLET CONTROL

The section of the culvert between HW#1 and HW#2 receives additional flow from the two adjoining sub-areas. A total of 18.0 cfs enters the culverts from a catch basin located over the culvert, which should be sized and located according to the CATCH BASIN DESIGN AND PIPE SYSTEM DESIGN sections contained in this manual. It will be assumed that the additonal flow is carried equally by both pipes.

An accumulated discharge of 96.5 cfs now exits at the outlet. Therefore, outlet control should be checked there if the entire culvert is to be sized as a unit.

The difference in the invert at headwall #1 and headwall #2, is 2 feet. Since there is no flood data on the downstream channel, it can be assumed that the tailwater depth is equal to the culvert diameter. The equation HW = H + ho - LSo shown on Chart No. SD-h expresses the relationship between the inlet and outlet.

Given: Maximum HW = 3.6', LSo = 2.0', ho = 3.0'

H = HW + LSo - ho .... H = 3.6 + 2.0 - 3.0 = 2.6' = Maximum Allowable Head

To check for outlet control, enter Chart No SD-h (use a "ke" = D.5 from Chart SD-11 and a length of 100 feet).

Q = 48.25, D = 2 x (36") .... H = 1.6' Actual Head

HW = H + ho - LSo .... HW = 1.6 + 3 - 2 = 2.6' Actual Head < Maximum Allowable Head

Since both inlet and outlet control check and the street elevation is high enough not to be flooded, the 2 x (36") concrete pipe is adequate.

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PIPE SYST .. DESIGN

Once all the catch basins have been located according to the catch basin design (post-development) procedures, the next step is to design the pipe systems to serve the basins. For the purpose of this manual and for the City of Greenville, pipes within the system shall be designed to carry a 10-year storm. The sizing of these pipes shall be based on the Manning Equation. It should be noted that the velocities for pipes shall be maintained between 2.5 feet per second and 10 feet per second. In addition, points of discharge should be treated in such a manner to conform with the State and local ordinances on velocity controls. This design is based on the sum of the individual areas served by the catch basins and not the sum of the capacities of each basin.

The storm drainage design data sheet, Chart SD-6 or an approved equivalent should be completed and submitted with each Plan. ~~preliminary plat. Example: See Chart SD-7 (Use example under Catch Basin Design and Chart SD-7 and SD-8).~~

Step 1: Note location of pipe one, from catch basin five to catch basin four.

Step 2: Note that the individual area drained by catch basin five is 1.4 acres as well as the sum of the areas to this point.

Step 3: List the coefficient of runoff for this type of development. For this example, C = 0.55.

Step 4: List the height above the most remote point above the outlet, the maximum length of travel, and determine the time of concentration according to the standard runoff calculation procedures. In turn, derive an intensity and place it in the proper location on the chart.

Step 5: Determine the runoff for the area served by pipe one.

Step 6: Assume a concrete pipe - the "n" factor is given to be 0.012. Assume a slope of 0.5% with a length of 32 feet. In addition, assume a 15 inch pipe. This would yield a velocity of 4.0 feet per second and a capacity of 4.9 cubic feet per second. The capacity of 4.9 cubic feet per second is greater than the discharge of the area of 4.62 cubic feet per second. Therefore, pipe number one is O.K. (An alternate method to determine the pipe size and slope would be to begin with a velocity and then determine the slope or size). The remainder of the pipes are listed and noted in the storm drainage design data sheet.

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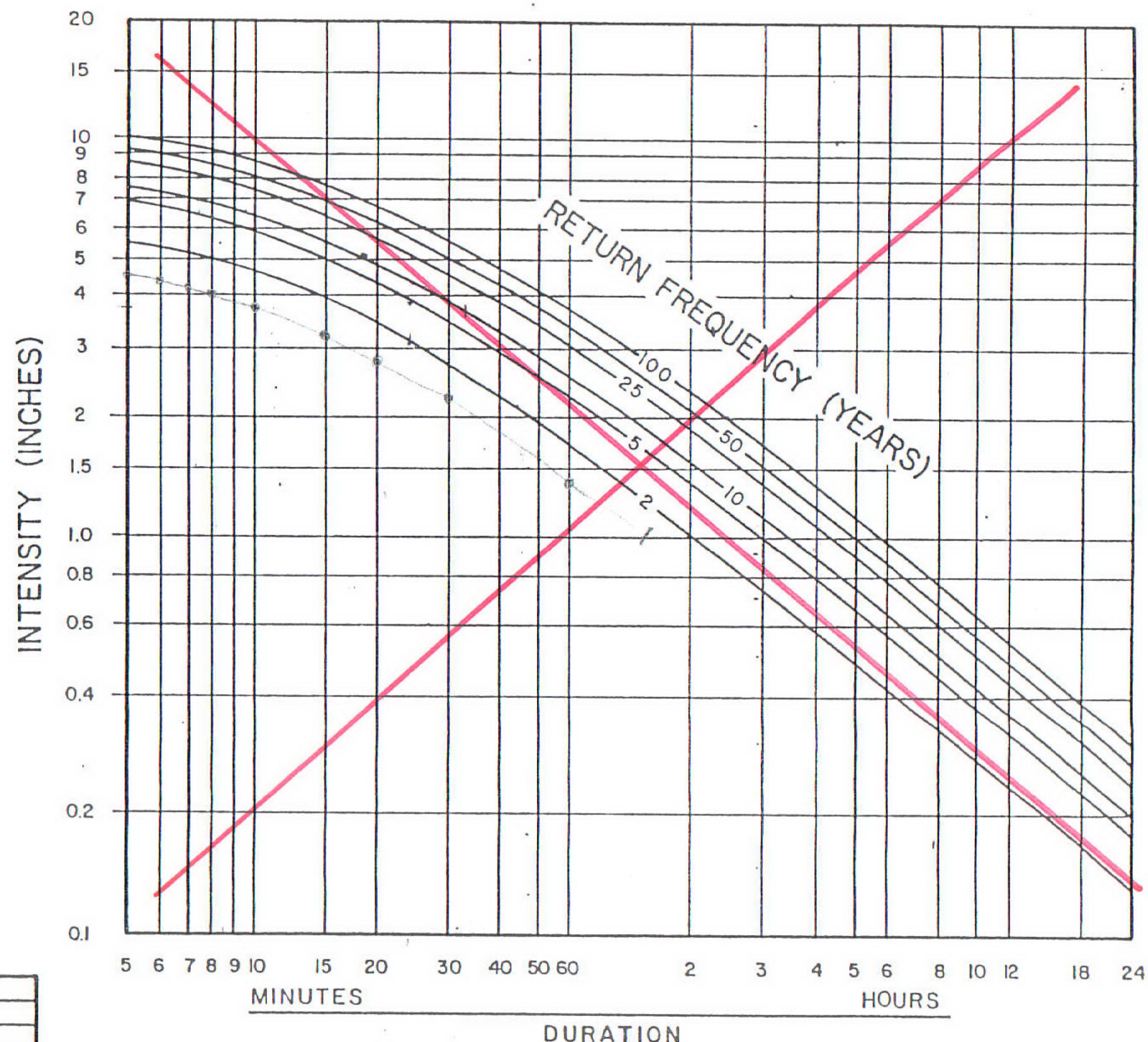
CHART SD-1



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NOTE: ASSUME TIME OF CONCENTRATION EQUALS DURATION

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RAINFALL INTENSITY VS. DURATION

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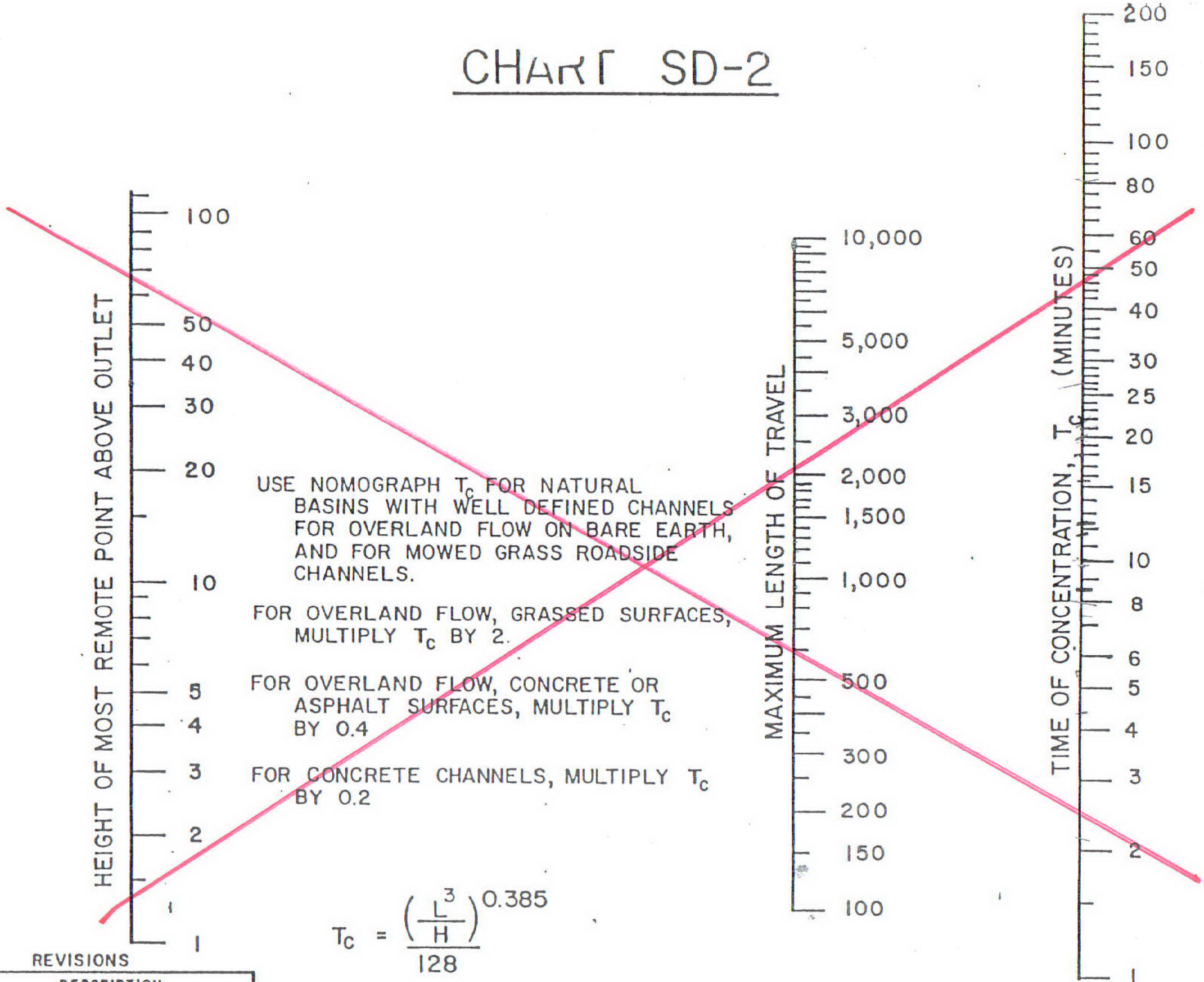
CHART SD-2



USE NOMOGRAPH T_c FOR NATURAL BASINS WITH WELL DEFINED CHANNELS FOR OVERLAND FLOW ON BARE EARTH, AND FOR MOWED GRASS ROADSIDE CHANNELS.

FOR OVERLAND FLOW, GRASSED SURFACES, MULTIPLY T_c BY 2.

FOR OVERLAND FLOW, CONCRETE OR ASPHALT SURFACES, MULTIPLY T_c BY 0.4

FOR CONCRETE CHANNELS, MULTIPLY T_c BY 0.2

$$T_c = \frac{\left(\frac{L^3}{H}\right)^{0.385}}{128}$$

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15.13	

RUNOFF CO[illegible]ICIENTS

LAWNS:	(1) SANDY SOILS	FLAT	< 2%	0.10
		AVERAGE	2% – 7%	0.15
		STEEP	> 7%	0.20
	(2) HEAVY SOILS	FLAT	< 2%	0.15
		AVERAGE	2% – 7%	0.20
		STEEP	> 7%	0.30

WOODS, CEMETERIES, PARKS	0.20
UNIMPROVED AREAS (PASTURE, CROP, ETC.)	0.25
PLAYGROUNDS	0.30

RESIDENTIAL:	(1) APARTMENTS AND TOWNHOUSES	0.70
	(2) LOT SIZE < 1/4 ACRE (R-6, R-9)	0.60
	(3) LOT SIZE < 1/3 ACRE (R-15)	0.55
	(4) LOT SIZE < 1/2 ACRE (R-20)	0.50
	(5) LOT SIZE < 1.0 ACRE	0.40
	(6) LOT SIZE > 1.0 ACRE	0.35
INDUSTRIAL:	(1) LIGHT	0.70
	(2) HEAVY	0.80
COMMERCIAL:	(1) DOWNTOWN, STRIP, MALL, PAVEMENT AREAS	0.95
	(2) CENTER	0.90
	(3) NEIGHBORHOOD	0.85

ROOF: 0.95

PAVEMENT: (1) Asphalt or concrete 0.90

(2) Brick 0.80

GRAVEL: 0.30

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CHART SD-3

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RUNOFF COEFFICIENTS

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15.14	

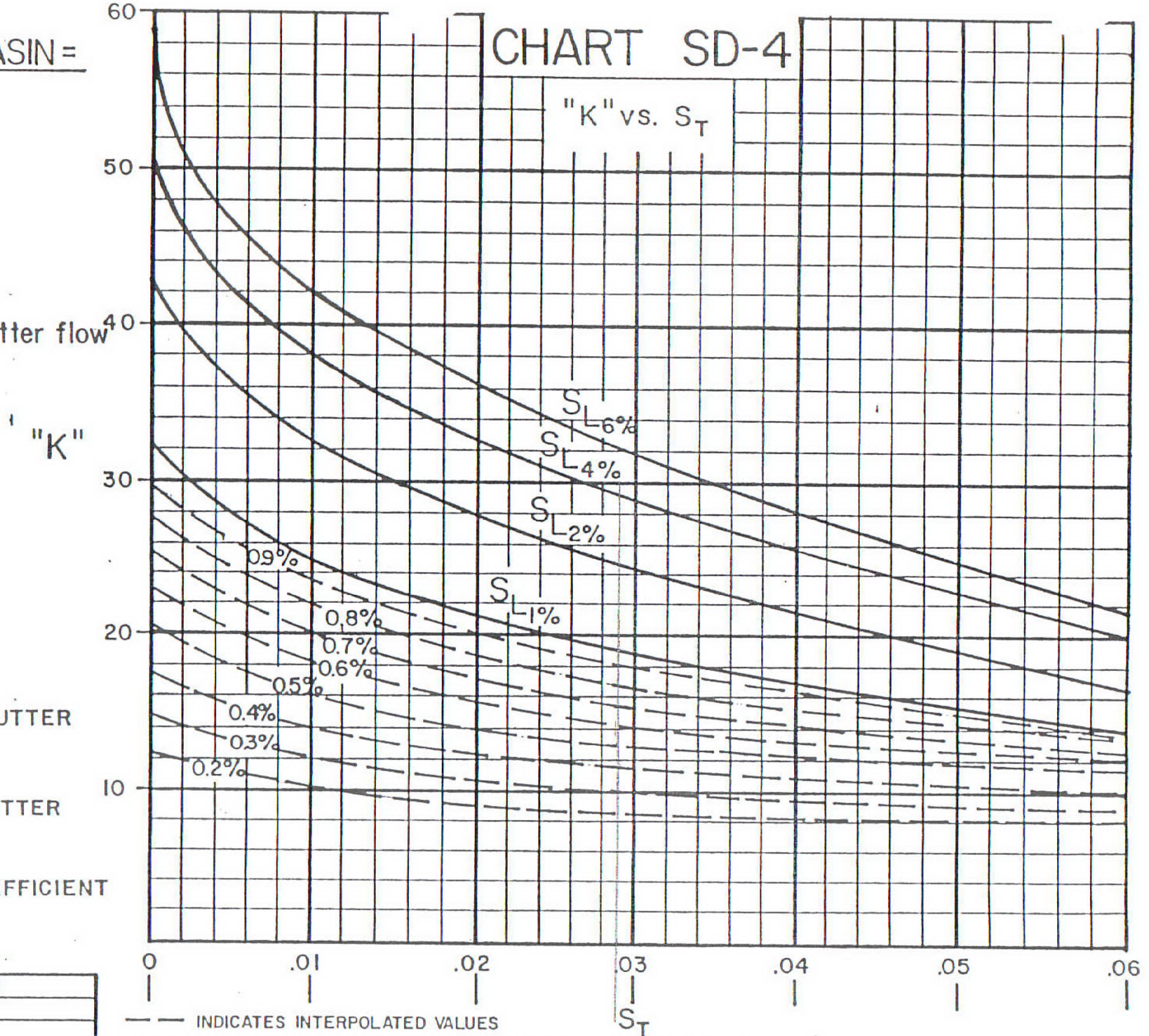
CAPACITY OF BASIN =

$$Q = K D^{5/3}$$

WHERE:

Q = C.F.S.

D = Depth of gutter flow in feet



S_L = LONGITUDINAL GUTTER SLOPE

S_T = TRANSVERSE GUTTER SLOPE

K = GRATE INLET COEFFICIENT

— — INDICATES INTERPOLATED VALUES

S_T = VERTICAL DISTANCE FROM CROWN TO GUTTER LINE DIVIDED BY DISTANCE FROM CREST OF ROADWAY (USUALLY ℄) TO GUTTER LINE.

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STANDARD CATCH BASIN INLET CAPACITY

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CATCH BASIN -SIGN DATA SHEET

PROJECT__________ COMPUTED BY__________ DATE________, 19___

LOCATION__________ CHECKED BY__________ DATE________, 19___

STORM FREQUENCY_____ YEARS

	1	2	3	4	5	6	7	8	9	10	11	12	13	
CATCH BASIN NO.	LONGITUDINAL STREET GRADE (S_L)%	TRANSVERSE STREET GRADE (S_T)	MAX. DEPTH OF OF FLOW IN GUTTER (FT.)	CAPACITY OF BASIN (C.F.S.) $Q=KD^{5/3}$	TRIAL COEF. OF RUNOFF	TRIAL INTENSITY (in.)	DERIVED AREA $= \frac{4}{5 \times 6}$	LENGTH OF DRAINAGE AREA	HEIGHT ABOVE MOST REMOTE POINT	COEF. OF RUNOFF	TIME OF CONCENTRATION (T_c)	ACTUAL INTENSITY (in.)	MAX. ALLOWABLE DRAINAGE AREA $= \frac{4}{10 \times 12}$	REMARKS (COLUMN 13 MUST BE W/N 10% OF COLUMN 7)

REVISIONS

NO.	DATE	DESCRIPTION

CHART SD-5

APPROVED: DATE May 8, 1980

CITY OF GREENVILLE, N.C. – ENGINEERING DEPT.

STD. NO.	REV.
15.16	

STORM DRAINAGE DESIGN DATA SHEET

PROJECT ______________________ DESIGNED BY ______________ DATE ______________, 19 ____

LOCATION ______________________ CHECKED BY ______________ SHEET ________ OF ________

STORM FREQUENCY _____ YEAR

LOCATION		AREA (ACRE)		C	INTENSITY			Q=CIA (C.F.S. REQ'D)	PIPE DATA							HGL	REMARKS
FROM	TO	SUB TOTAL	TOTAL		H	L	I		TYPE	N	S%	LENGTH	SIZE	VEL. (OF Q REQ'D)	Q AVAIL.		

REVISIONS

NO.	DATE	DESCRIPTION

C – RUNOFF COEFFICIENT
H – HEIGHT ABOVE INLET OF MOST REMOTE POINT
L – LENGTH OF DRAINAGE AREA
I – INTENSITY OF STORM (INCHES)
N – COEFFICIENT OF FRICTION
S – SLOPE (%)
Q – FLOW (C.F.S.)

NOTE: DESIGN IS BASED ON THE SUM OF THE AREAS AND NOT THE SUM OF THE DISCHARGES.

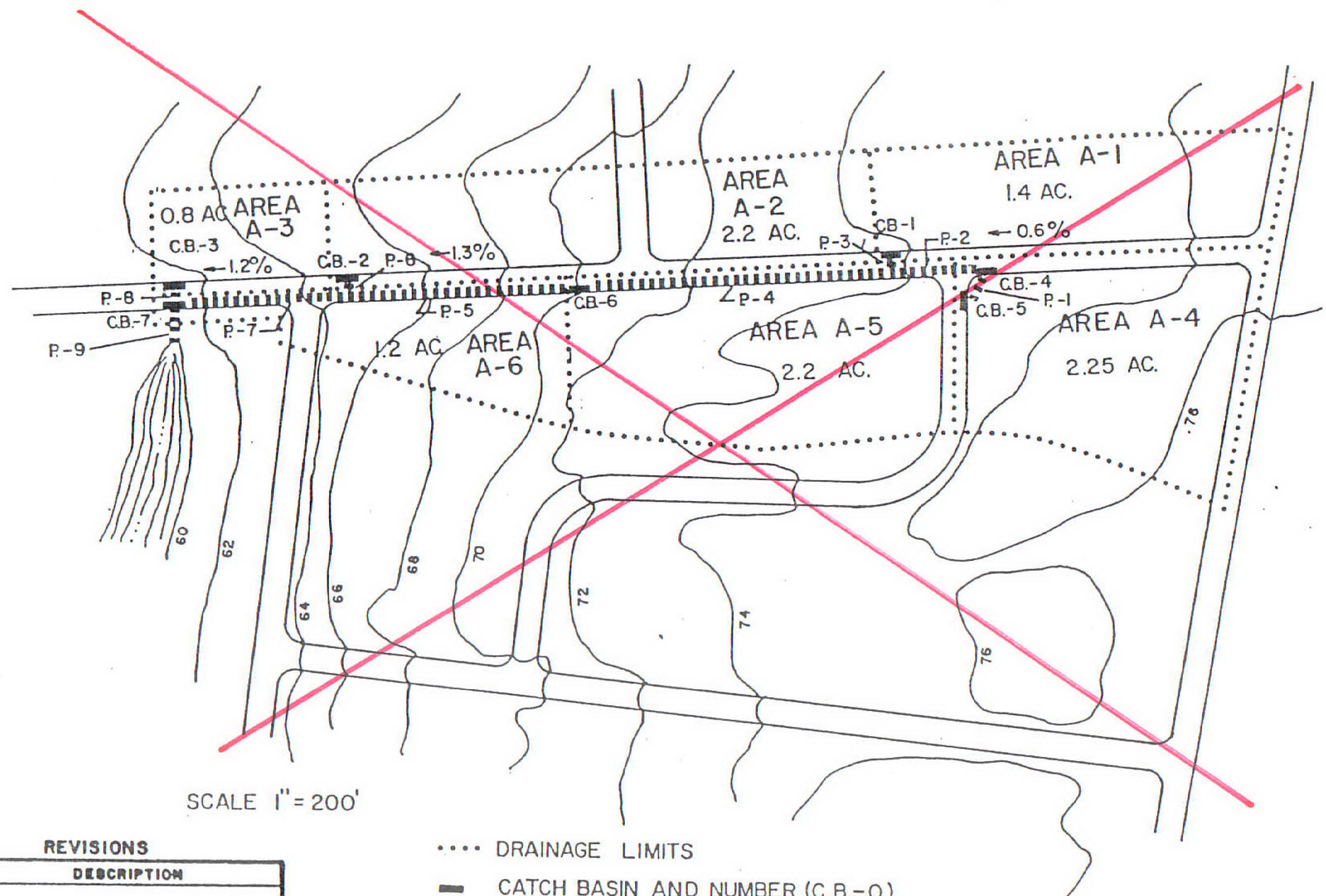
CHART SD-6

APPROVED: DATE May 8, 1980

CITY OF GREENVILLE, N.C. – ENGINEERING DEPT.

STD. NO.	REV.
15.17	

CHART SD-7



SCALE 1" = 200'

REVISIONS

NO.	DATE	DESCRIPTION

···· DRAINAGE LIMITS

▬ CATCH BASIN AND NUMBER (C.B.-O)

▪▪▪▪ PIPE AND SECTION NUMBER (P.-O)

APPROVED: DATE May 8, 1980

CITY OF GREENVILLE N.C. — ENGINEERING DEPT.

STD. NO.	REV.
15.10	

CATCH BASIN DESIGN DATA SHEET

PROJECT *EXAMPLE* COMPUTED BY ______ DATE ______, 19__

LOCATION *SOMEWHERE SUB. DIV.* CHECKED BY ______ DATE ______, 19__

STORM FREQUENCY *2* YEARS

CATCH BASIN NO.	1 LONGITUDINAL STREET GRADE (S_L)%	2 TRANSVERSE STREET GRADE (S_T)	3 MAX. DEPTH OF OF FLOW IN GUTTER (FT.)	4 CAPACITY OF BASIN (C.F.S.) $Q=KD^{5/3}$	5 TRIAL COEF. OF RUNOFF	6 TRIAL INTENSITY (in.)	7 DERIVED AREA $= \frac{4}{5 \times 6}$	8 LENGTH OF DRAINAGE AREA	9 HEIGHT ABOVE MOST REMOTE POINT	10 COEF. OF RUNOFF	11 TIME OF CONCENTRATION (T_c)	12 ACTUAL INTENSITY (in.)	13 MAX. ALLOWABLE DRAINAGE AREA $= \frac{4}{10 \times 12}$	REMARKS (COLUMN 13 MUST BE W/N 10% OF COLUMN 7)
1	0.6	0.029	0.5	4.41	0.55	5.5	1.46	500	3	0.55	7	5.2	1.54	O.K.
2	1.3	"	"	6.61	"	"	2.19	680	9	"	6	5.3	2.27	O.K.
3	1.2	"	"	6.30	"	"	2.08	250	4	"	5	5.5	2.08	O.K.
4	0.6	"	"	4.41	"	"	1.46	400	4	"	5	5.5	1.46	ADD CB-5
5	"	"	"	4.41	"	"	"	"	"	"	"	"	"	O.K.
6	1.3	"	"	6.61	"	"	2.19	500	6	"	5	"	2.19	O.K.
7	1.2	"	"	6.3	"	"	2.08	500	10	"	5	"	2.08	O.K.

REVISIONS

NO.	DATE	DESCRIPTION

CHART SD-8

APPROVED: DATE May 8, 1980

CITY OF GREENVILLE, N.C. — ENGINEERING DEPT.

STD. NO.	REV.
15 19	

STORM DRAINAGE DESIGN DATA SHEET

PROJECT *EXAMPLE* DESIGNED BY ______ DATE ______, 19 ___

LOCATION *SOMEWHERE SUB.DIV.* CHECKED BY ______ SHEET ___ OF ___

STORM FREQUENCY *10* YEAR

LOCATION		AREA (ACRE)		C	INTENSITY			Q=CIA (C.F.S. REQ'D)	PIPE DATA							REMARKS
FROM	TO	SUB TOTAL	TOTAL		H	L	I		TYPE	N	S%	LENGTH	SIZE	VEL. (OF Q REQ'D)	Q AVAIL.	
CB-5	CB-4	1.125	1.125	0.55	4'	400'	7.5	4.6	CONC	0.012	0.5	32'	15"	4.0	4.9	Pipe-1-O.K.
CB-4	—	1.125	1.125	0.55	4'	400'	7.5	4.6	—	—	—	—	—	—	—	DROP INLET NO PIPE REQUIRED
CB-4	T-CB-1	—	2.25	0.55	4'	400'	7.5	9.3	CONC.	0.012	0.7	120'	18"	5.4	9.5	Pipe-2-O.K.
CB-1	T-CB-1	1.40	1.40	0.55	3'	500'	7.1	5.5	CONC.	0.012	1.0	32'	15"	5.7	7.0	Pipe-3-O.K.
T-CB-1	CB-6	1.40	3.65	0.55	3'	500'	7.1	14.3	CM	0.023	1.0	390'	24"	4.7	14.7	Pipe-4-O.K.
CB-6	—	2.20	2.20	0.55	6'	500'	7.5	9.1	—	—	—	—	—	—	—	DROP INLET NO PIPE REQUIRED
CB-6	T-CB-2	—	5.85	0.55	8'	1000'	6.4	20.6	CM	0.023	1.0	290'	30"	4.7	23.2	Pipe-5-O.K.
CB-2	T-CB-2	2.20	2.20	0.55	9'	650'	7.2	8.7	CONC.	0.012	0.6	32'	18"	5.0	8.8	Pipe-6-O.K.
T-CB-2	CB-7	—	8.05	0.55	12'	1200'	6.3	27.9	CM	0.023	1.0	210'	36"	4.1	28.9	Pipe-7-O.K.
CB-7	—	1.20	1.20	0.55	10'	500'	7.5	5.0	—	—	—	—	—	—	—	DROP INLET No PIPE REQUIRED
CB-3	CB-7	0.8	0.8	0.55	3'	240'	7.5	3.3	CM	0.023	0.5	32'	15"	4.0	4.9	Pipe-8-O.K.
CB-7	OUTLET	—	10.05	0.55	14'	1400'	6.2	34.3	CM	0.023	0.9	50'	36"	5.1	35.7	Pipe-9-O.K.

REVISIONS

NO.	DATE	DESCRIPTION

C - RUNOFF COEFFICIENT
H - HEIGHT ABOVE INLET OF MOST REMOTE POINT
L - LENGTH OF DRAINAGE AREA
I - INTENSITY OF STORM (INCHES)
N - COEFFICIENT OF FRICTION
S - SLOPE (%)
Q - FLOW (C.F.S.)

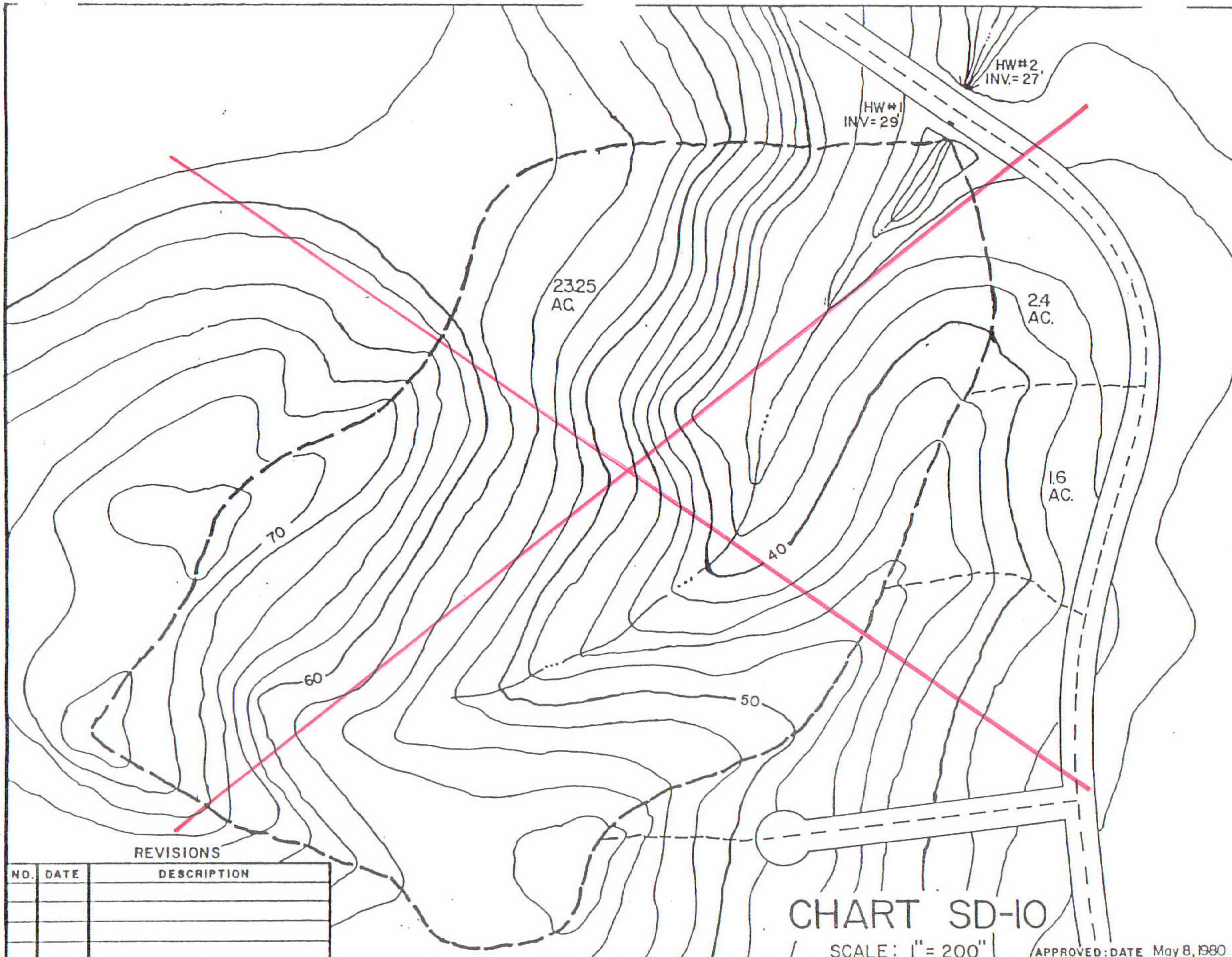
NOTE: DESIGN IS BASED ON THE SUM OF THE AREAS AND NOT THE SUM OF THE DISCHARGES.

CHART SD-9

APPROVED: DATE May 8, 1980

CITY OF GREENVILLE, N.C. — ENGINEERING DEPT.

STD. NO. 15.20 REV.



REVISIONS

NO.	DATE	DESCRIPTION

CHART SD-10

SCALE: 1" = 200'

APPROVED: DATE May 8, 1980

EXAMPLE - CULVERT DESIGN

CITY OF GREENVILLE N.C. — ENGINEERING DEPT

STD. NO.	REV.

COEFFICIENT OF ENTRANCE LOSS, "Ke"

TYPE OF STRUCTURE AND DESIGN OF ENTRANCE	COEFFICIENT Ke:
Pipe, Concrete	
Projecting from fill	0.5
Headwall or headwall and wingwalls	0.5
Mitered to conform to fillslope	0.7
Pipe or Pipe-Arch, Corrugated Metal	
Projecting (no headwall)	0.9
Headwall or headwall and wingwalls	0.5
Mitered to conform to fillslope	0.7
Box Reinforced Concrete	
Headwall	0.5
Wingwall at 30 degrees to 75 degrees to barrel	0.4
Wingwalls at 10 degrees to 25 degrees to barrel	0.5

REVISIONS

NO.	DATE	DESCRIPTION

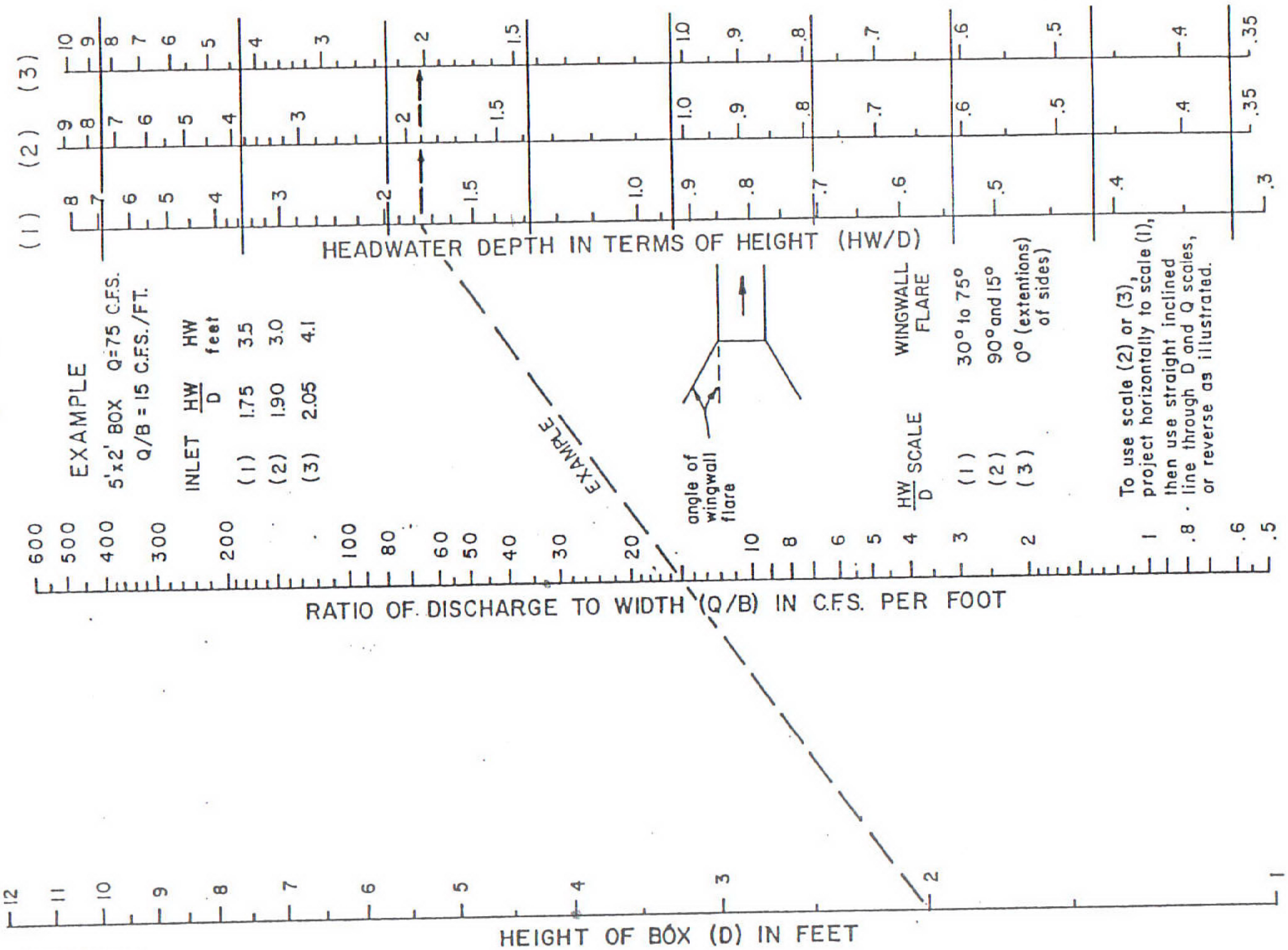
CHART SD-11

APPROVED:DATE May 8, 1980

CITY OF GREENVILLE, N.C.— ENGINEERING DEPT.

STD. NO.	REV.
1522	

CHAR' SD-a



BUREAU OF PUBLIC ROADS-JAN. 1963

REVISIONS		
NO.	DATE	DESCRIPTION

HEADWATER DEPTH FOR
BOX CULVERTS WITH
INLET CONTROL

APPROVED: DATE May 8, 1980

CULVERT DESIGN– INLET CONTROL

CITY OF GREENVILLE, N.C.– ENGINEERING DEPT.

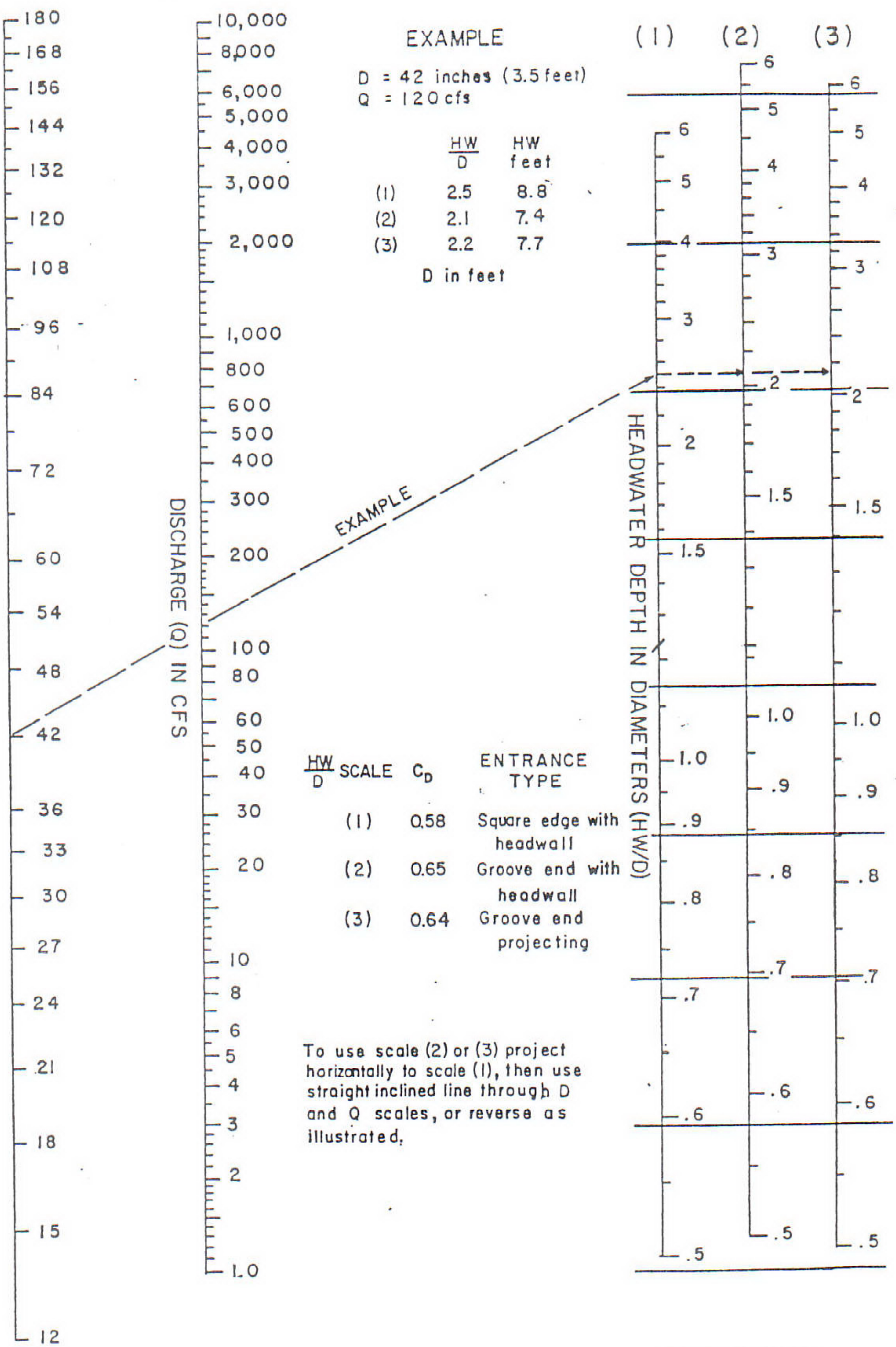
STD. NO.	REV.
15.23	

CITY OF GREENVILLE, N.C. – ENGINEERING DEPT.

NO.	DATE	DESCRIPTION

REVISIONS

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL



CHA SD-b

APPROVED: DATE May 8, 1980

BUREAU OF PUBLIC ROADS – JAN. 1963

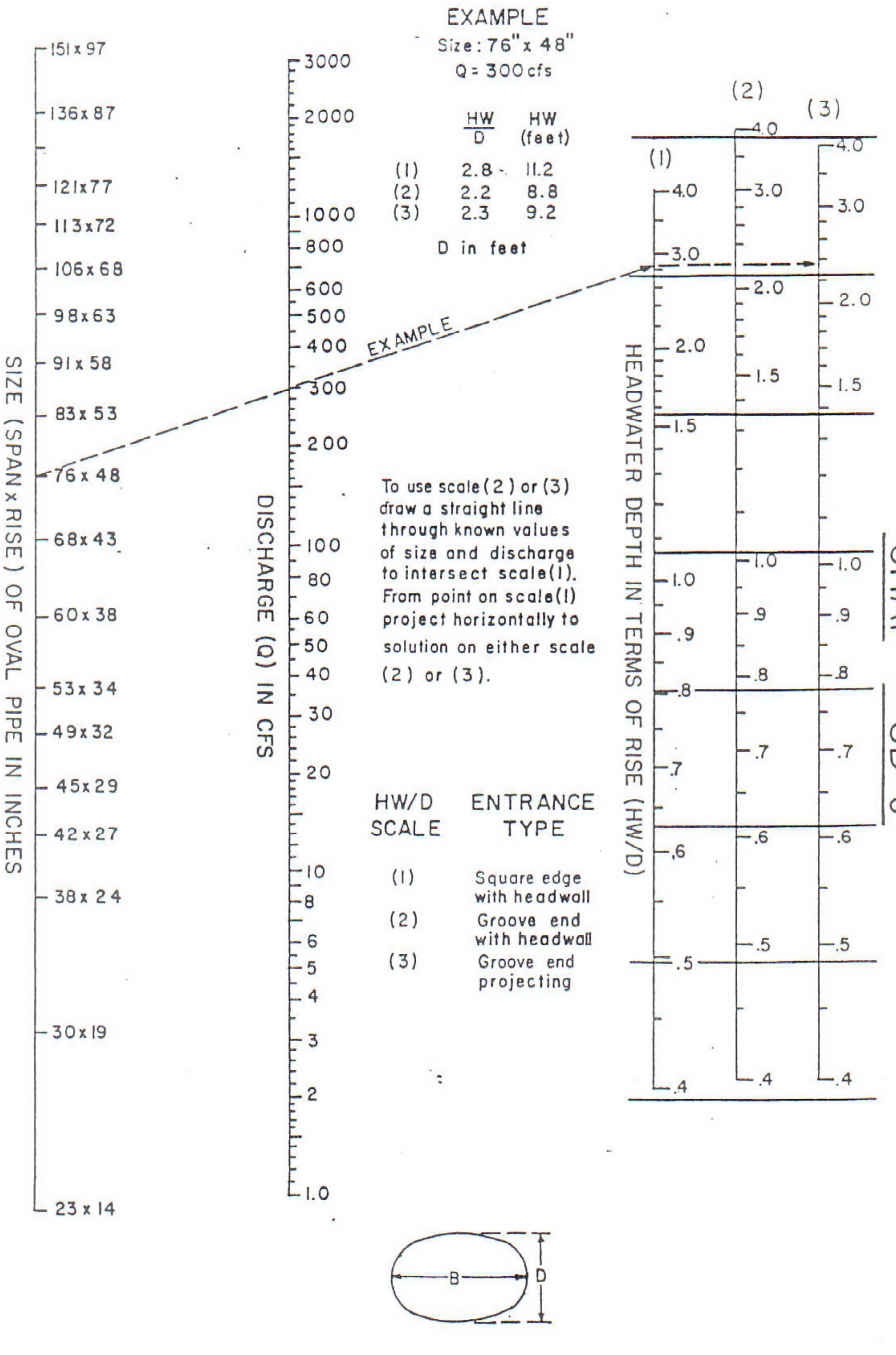
HEADWATER SCALES 2&3
REVISED MAY 1964

STD. NO. 15.24 REV.

CITY OF GREENVILLE, N.C.— ENGINEERING DEPT.

NO.	DATE	REVISIONS DESCRIPTION

HEADWATER DEPTH FOR OVAL CONCRETE PIPE CULVERTS LONG AXIS HORIZONTAL WITH INLET CONTROL



CHAF SD-C

BUREAU OF PUBLIC ROADS-JAN. 1963

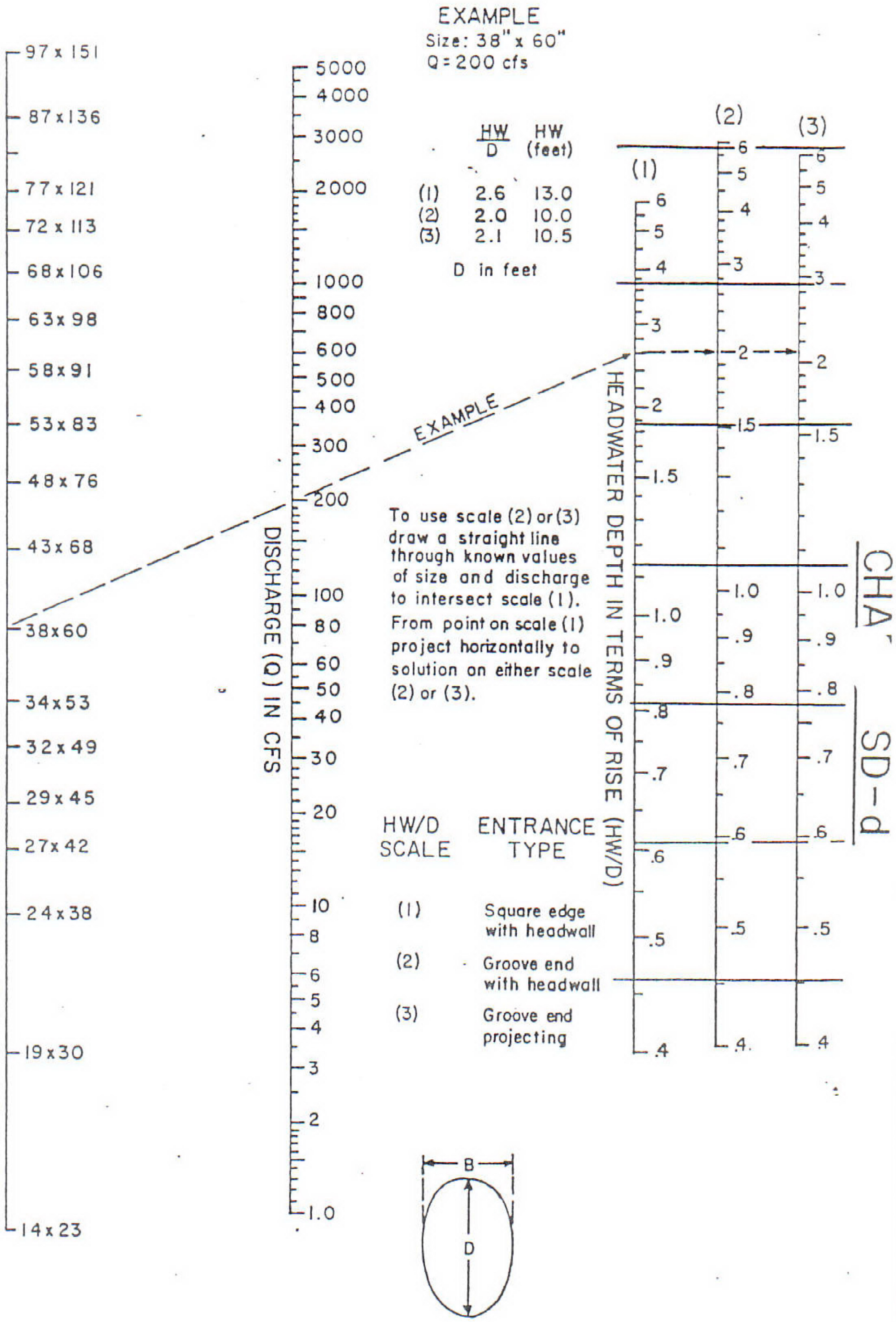
APPROVED: DATE May 8, 1980

STD. NO. 15.25 REV.

CITY OF GREENVILLE, N.C. – ENGINEERING DEPT.

NO.	DATE	REVISIONS DESCRIPTION

HEADWATER DEPTH FOR
OVAL CONCRETE PIPE CULVERTS
LONG AXIS VERTICAL
WITH INLET CONTROL



CHA – SD – d

BUREAU OF PUBLIC ROADS–JAN. 1963

APPROVED: DATE May 8, 1980

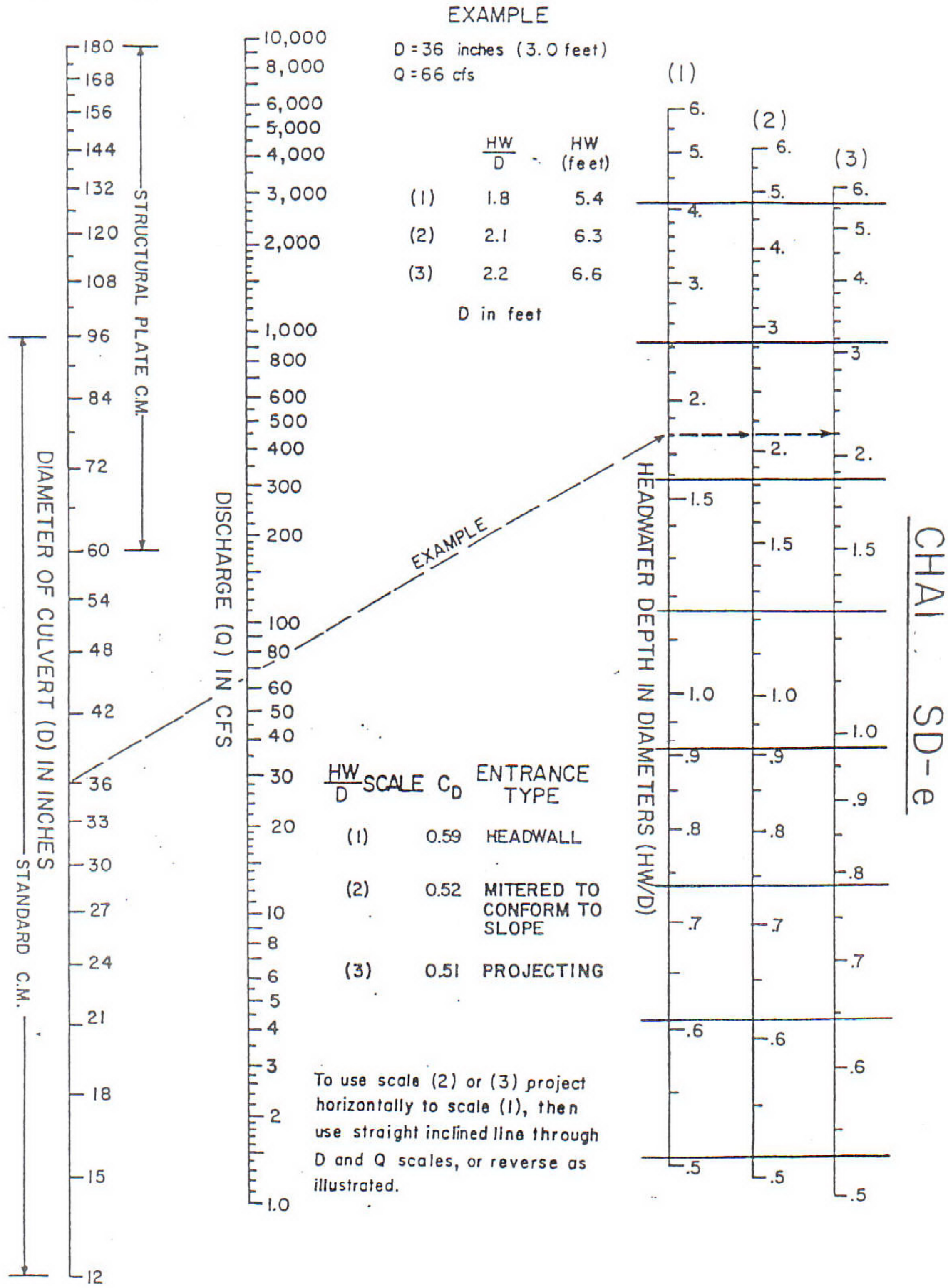
STD. NO. 15.26 | REV.

NO.	DATE	DESCRIPTION

REVISIONS

CITY OF GREENVILLE, N.C. — ENGINEERING DEPT.

HEADWATER DEPTH FOR C.M. PIPE CULVERTS WITH INLET CONTROL



BUREAU OF PUBLIC ROADS—JAN. 1963

APPROVED: DATE May 8, 1980

STD. NO.	REV.
1527	

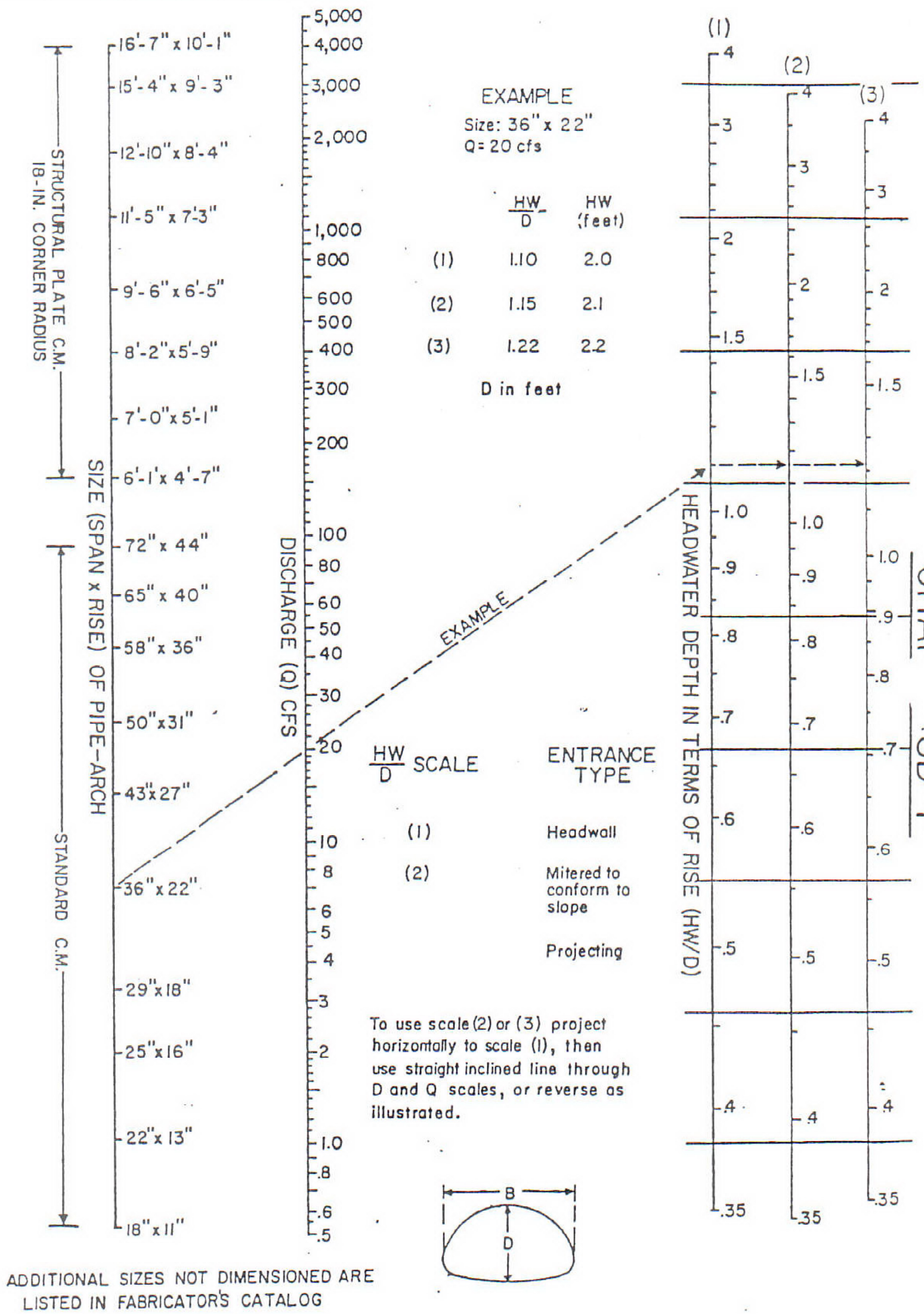
CHAI. SD-e

CITY OF GREENVILLE, N.C. — ENGINEERING DEPT.

NO.	DATE	DESCRIPTION

REVISIONS

HEADWATER DEPTH FOR C.M. PIPE-ARCH CULVERTS WITH INLET CONTROL



ADDITIONAL SIZES NOT DIMENSIONED ARE LISTED IN FABRICATOR'S CATALOG

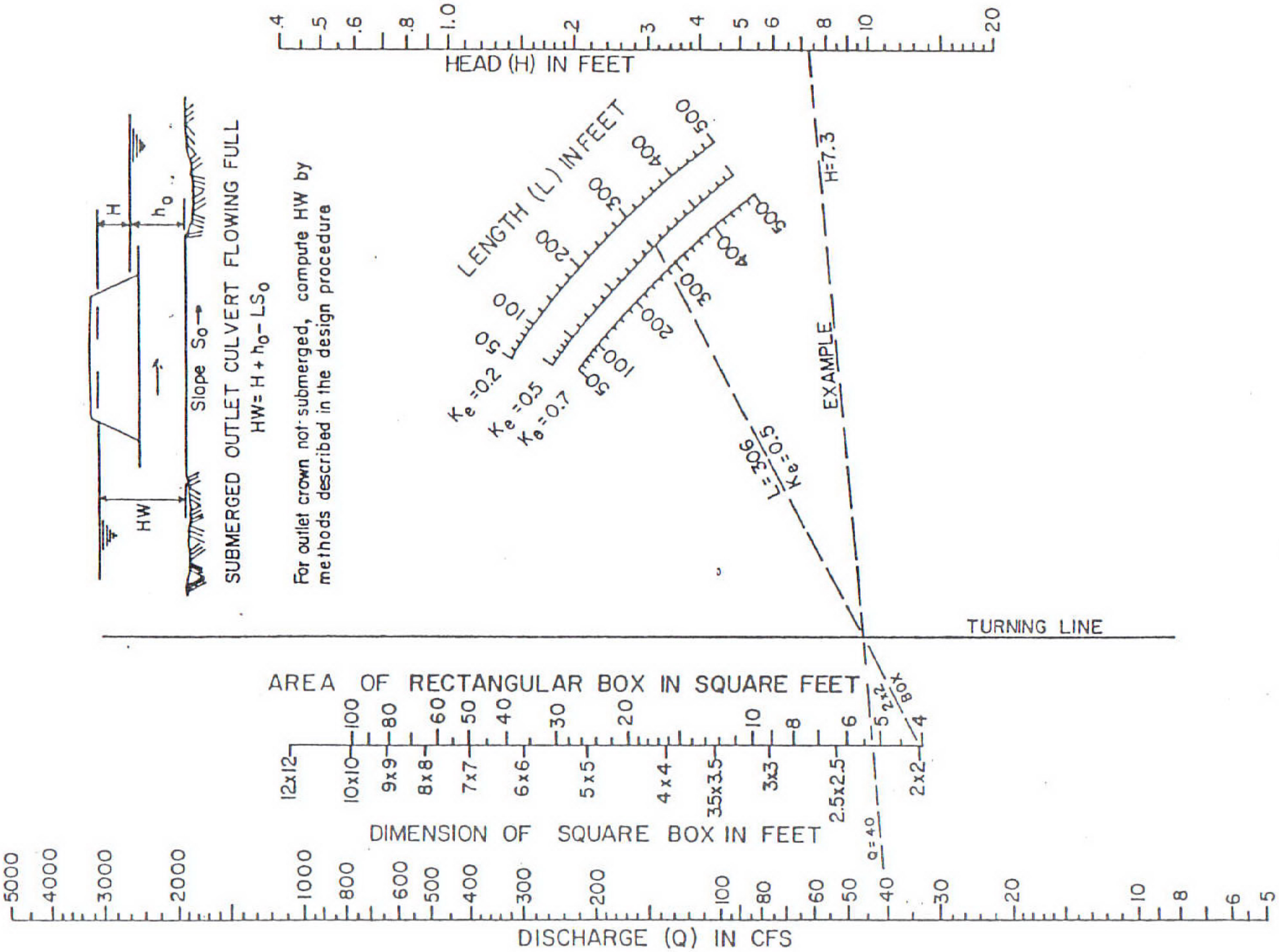
BUREAU OF PUBLIC ROADS — JAN. 1963

APPROVED: DATE May 8, 1980

CHAF SD-f

STD. NO.	REV.
15.2.8	

CHART SD-9



BUREAU OF PUBLIC ROADS-JAN. 1963

HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL

$n = 0.012$

REVISIONS

NO.	DATE	DESCRIPTION

APPROVED: DATE May 8, 1980

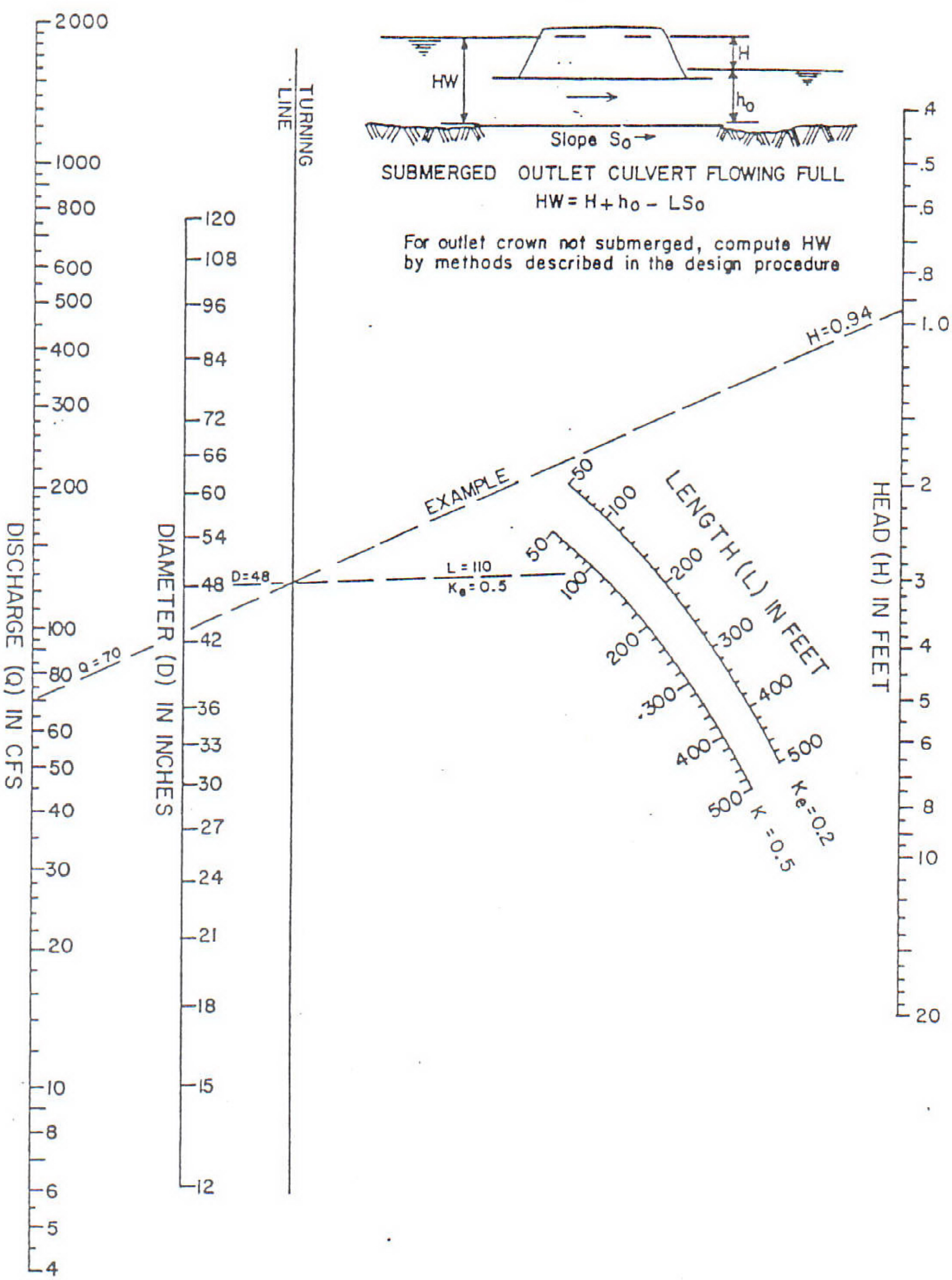
CITY OF GREENVILLE, N.C. — ENGINEERING DEPT.

STD. NO.	REV.
15.29	

CITY OF GREENVILLE, N.C. – ENGINEERING DEPT.

CHART SD-h

HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL
$n = 0.012$



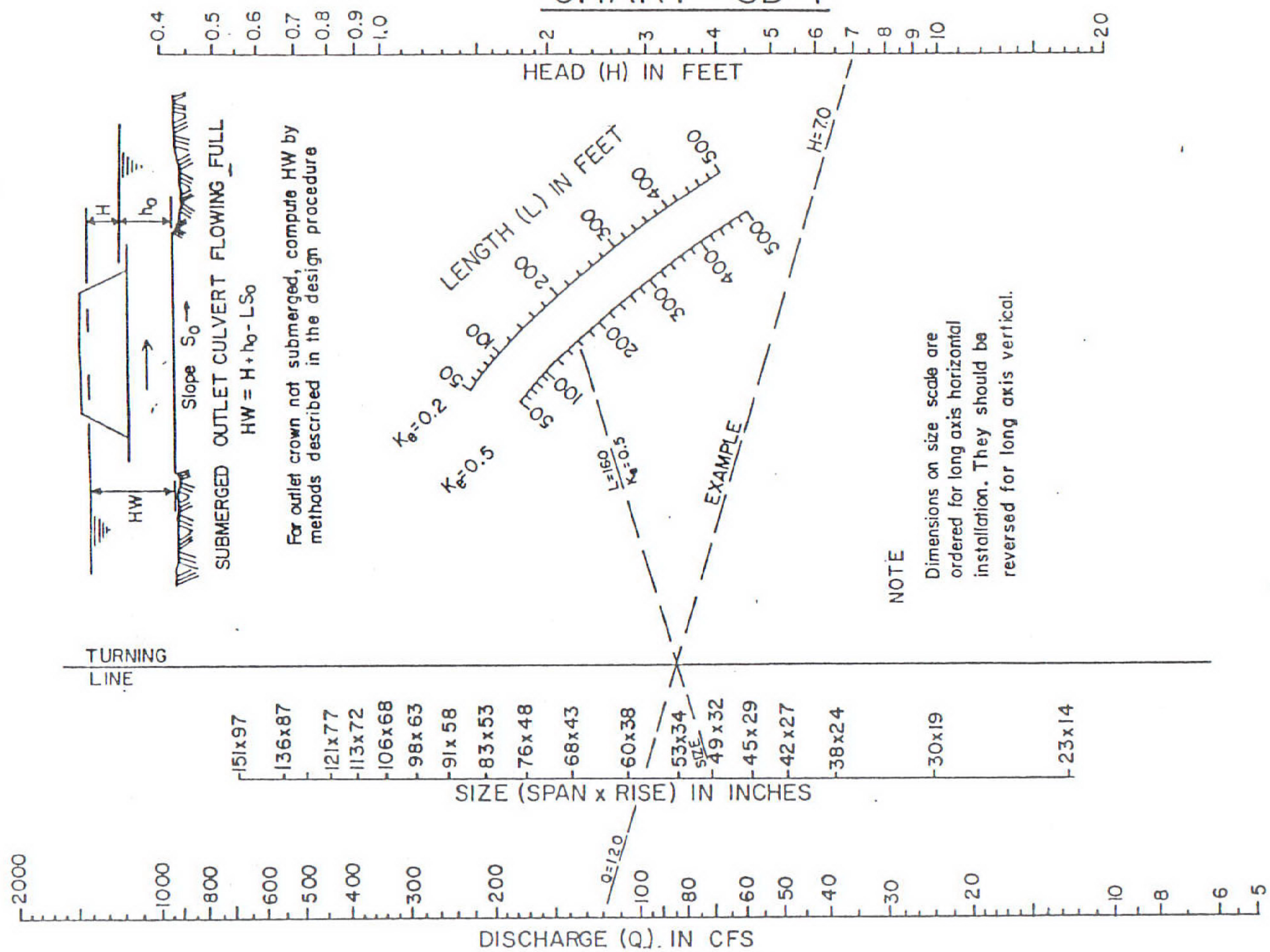
BUREAU OF PUBLIC ROADS—JAN. 1963

NO.	DATE	REVISIONS DESCRIPTION

APPROVED: DATE May 8, 1980

STD. NO. | REV.

CHART SD-1



HEAD FOR OVAL CONCRETE PIPE CULVERTS LONG AXIS HORIZONTAL OR VERTICAL FLOWING FULL

$n = 0.012$

BUREAU OF PUBLIC ROADS – JAN. 1963

REVISIONS

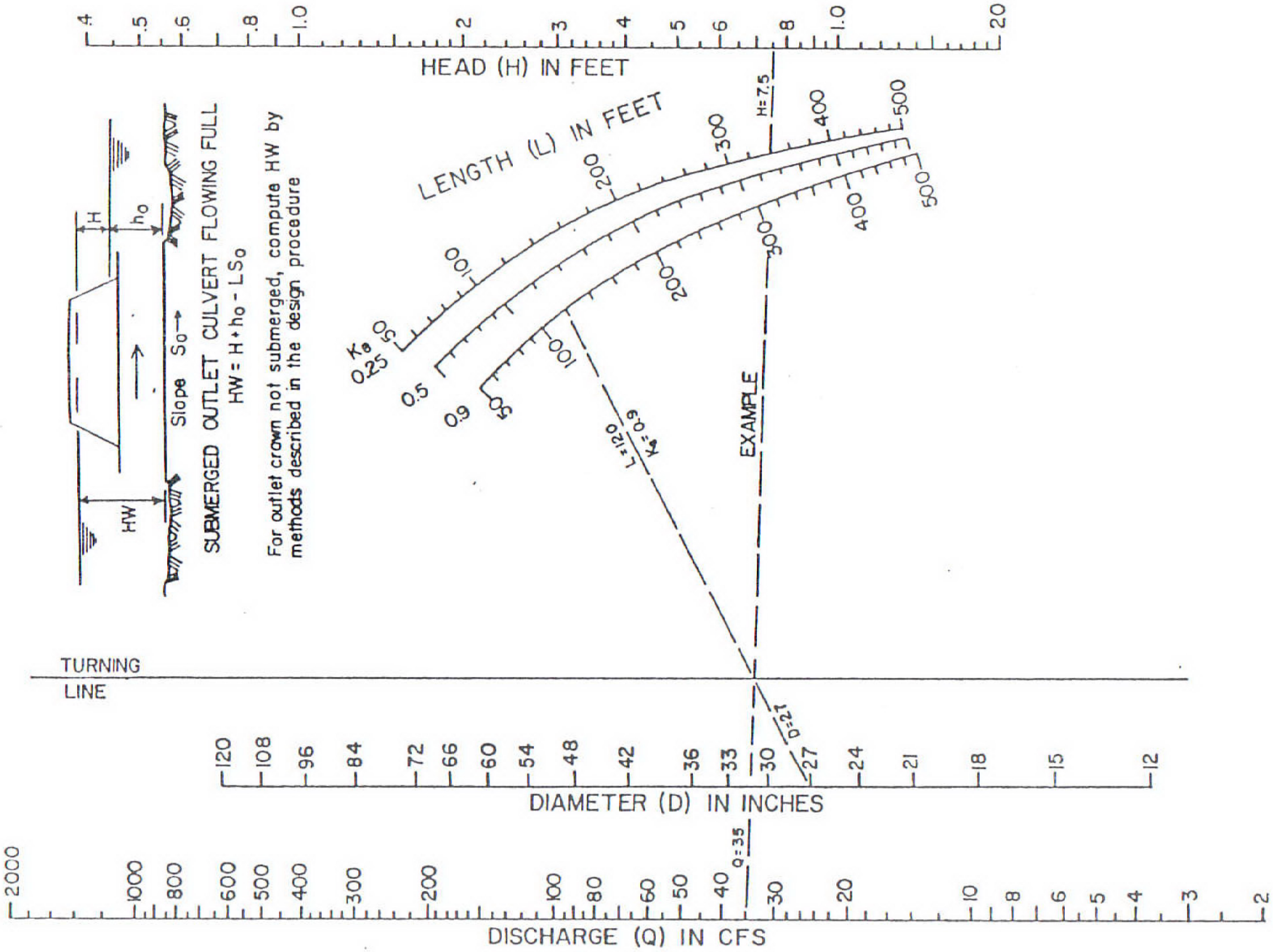
NO.	DATE	DESCRIPTION

APPROVED: DATE May 8, 1980

CITY OF GREENVILLE N.C. – ENGINEERING DEPT.

STD. NO.	REV.
15.31	

CHART SD-1



HEAD FOR
STANDARD
C. M. PIPE CULVERTS
FLOWING FULL
n=0.023

BUREAU OF PUBLIC ROADS – JAN. 1963

REVISIONS

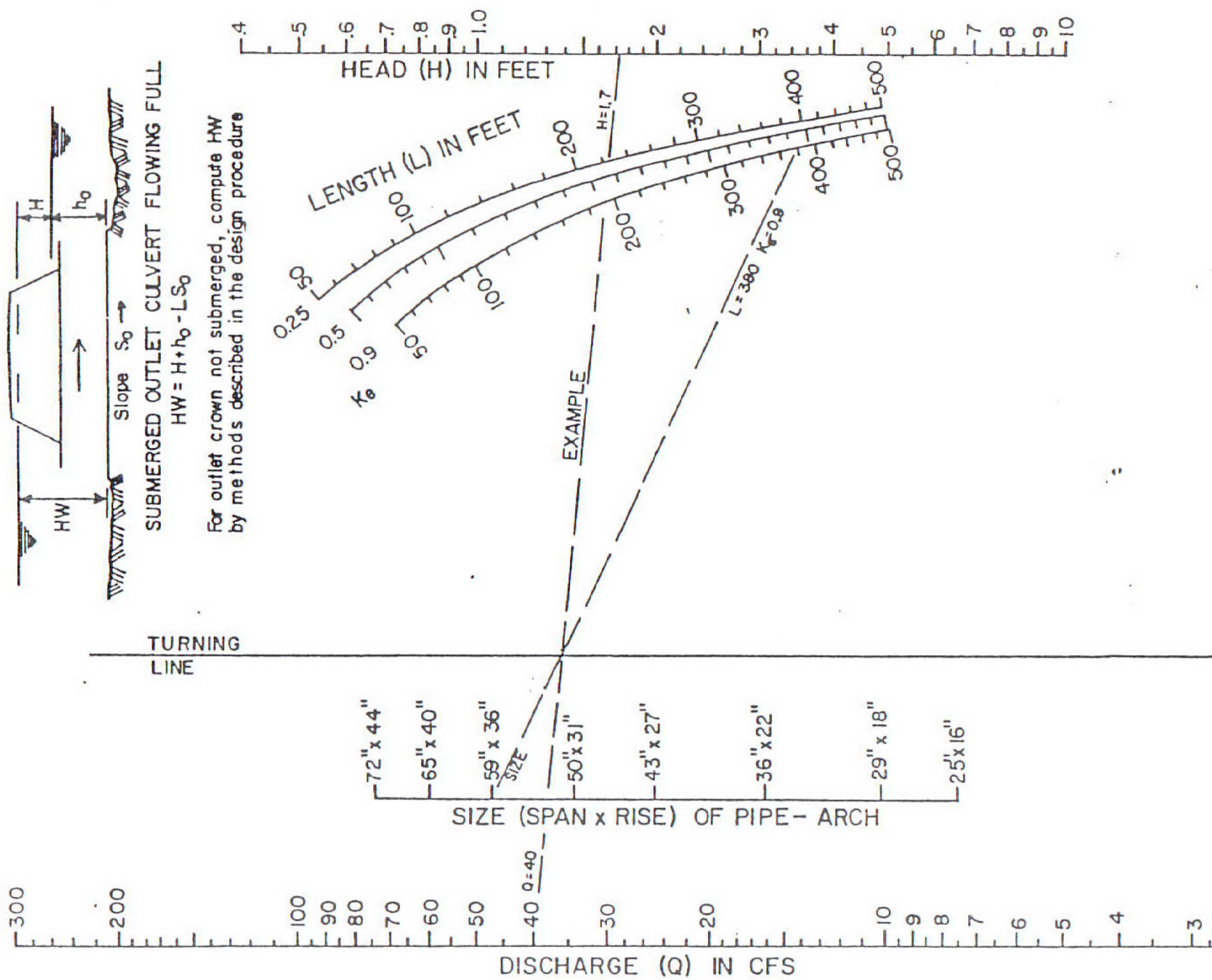
NO.	DATE	DESCRIPTION

APPROVED: DATE May 8, 1980

CITY OF GREENVILLE N.C. — ENGINEERING DEPT

STD. NO.	REV.

CHAR. SD-k



HEAD FOR
STANDARD C. M. PIPE-ARCH CULVERTS
FLOWING FULL
n=0.023

BUREAU OF PUBLIC ROADS-JAN. 1963

NO.	DATE	DESCRIPTION

REVISIONS

APPROVED: DATE May 8, 1980

CITY OF GREENVILLE, N.C.— ENGINEERING DEPT.

STD. NO.	REV.
15 33	

CITY OF GREENVILLE, N.C. — ENGINEERING DEPT.

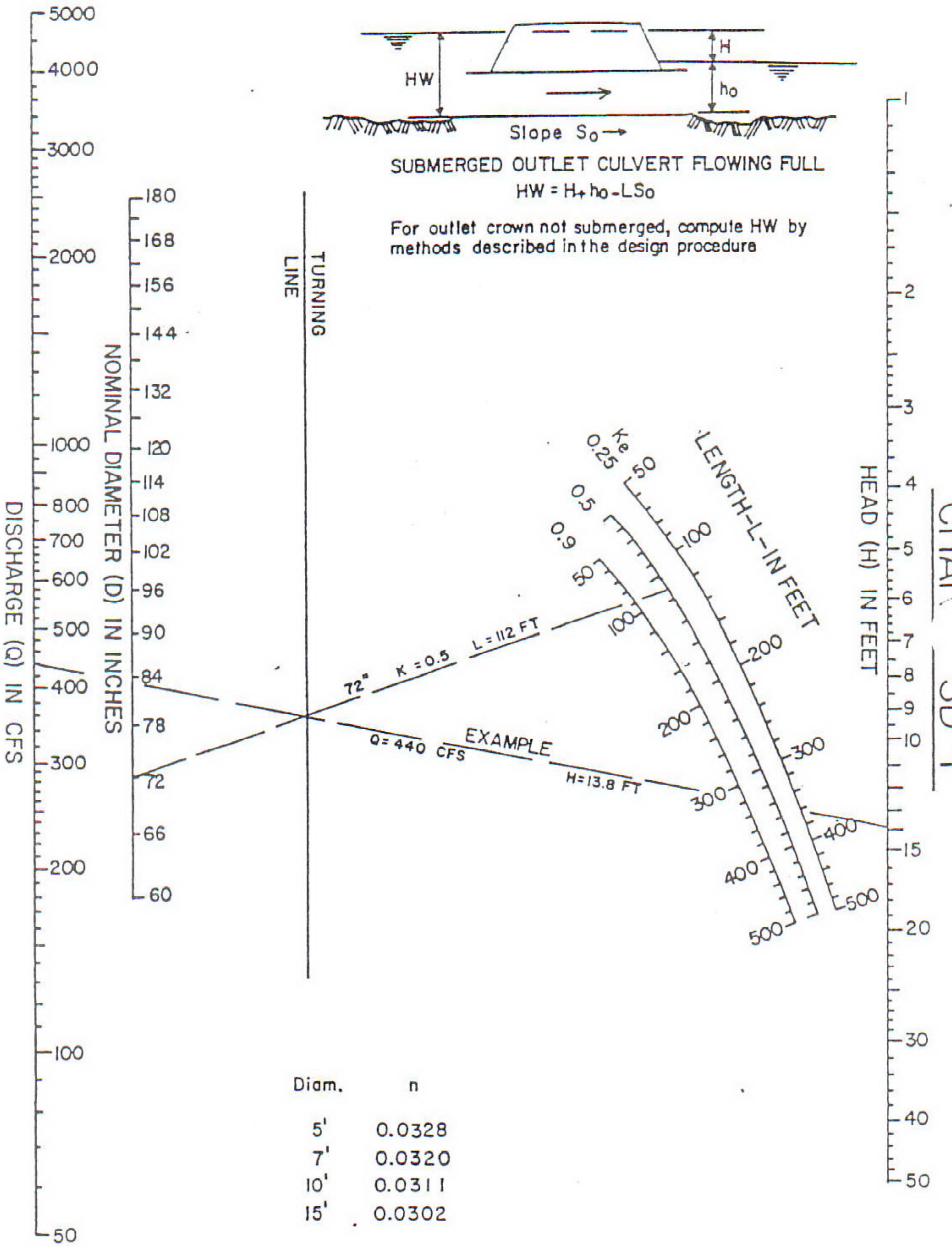
NO.	DATE	DESCRIPTION

REVISIONS

HEAD FOR STRUCTURAL PLATE CORR. METAL PIPE CULVERTS FLOWING FULL

$n = 0.0328$ TO 0.0302

CHAF SD-1



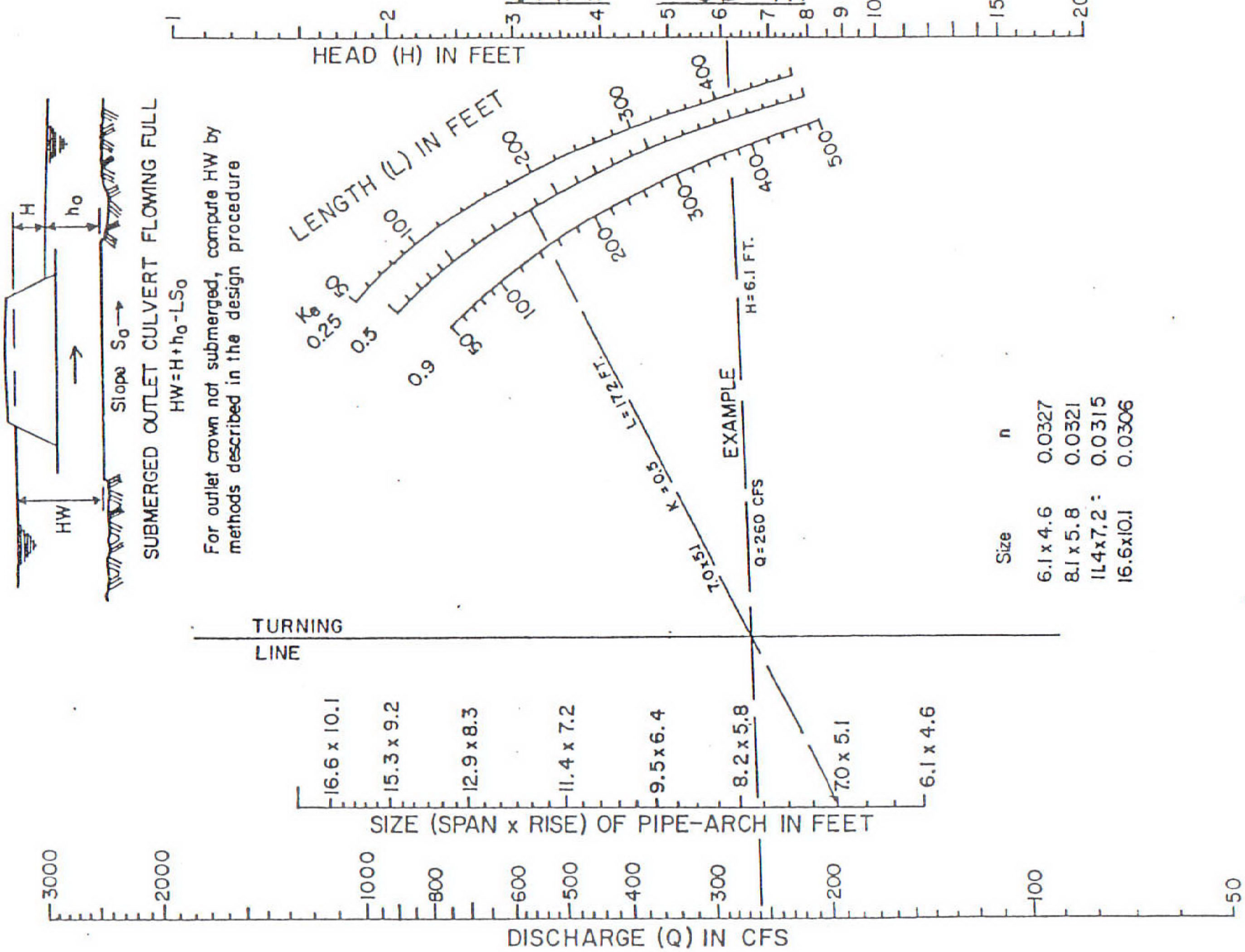
Diam.	n
5'	0.0328
7'	0.0320
10'	0.0311
15'	0.0302

APPROVED: DATE May 8, 1980

STD. NO. | REV.

BUREAU OF PUBLIC ROADS—JAN. 1963

CHART SD-m



Size	n
6.1 x 4.6	0.0327
8.1 x 5.8	0.0321
11.4x7.2	0.0315
16.6x10.1	0.0306

BUREAU OF PUBLIC ROADS-JAN. 1963

HEAD FOR STRUCTURAL PLATE CORRUGATED METAL PIPE ARCH CULVERTS 18 IN. CORNER RADIUS FLOWING FULL

$n = 0.0327$ TO 0.0306

REVISIONS

NO.	DATE	DESCRIPTION

APPROVED: DATE May 8, 1980

CITY OF GREENVILLE, N.C.— ENGINEERING DEPT.

STD. NO.	REV.
15.35	